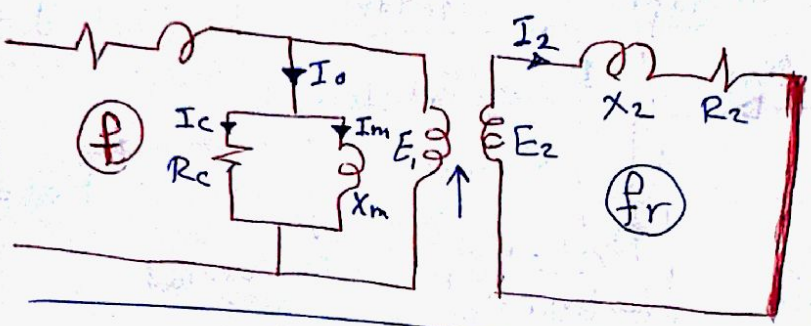
E. Machines 7-5-2015

Lecture 10: Equivalent circuit of I.M & Efficiency (2%)

Outline

1. Equivalent circuit of I.M
2. Losses & Efficiency

1 Equivalent circuit of I.M



f_r → تردد الجهد المتولد في العضو الدوار

f → تردد المصدر للعضو الثابت

Stand still

$S=1$

$f_r = Sf = f$

induced emf of rotor/Phase $= E_2$

Running

$0 < S < 1$

$f_r = Sf$

induced voltage/Phase $= SE_2$

R_2 = Rotor winding resistance/Phase $= R_2$

$X_2 = 2\pi f L_2 = (\omega L)$

$Z_2 = \sqrt{R_2^2 + X_2^2}$

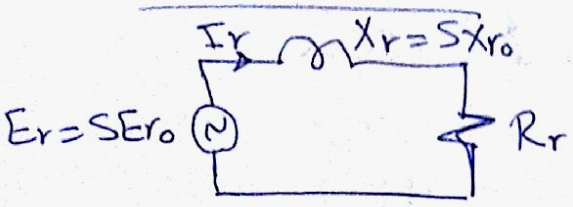
$I_2 = E_2 / Z_2$

$X_2' = SX_2 = 2\pi f_r L$

$Z_2' = \sqrt{R_2^2 + (SX_2)^2}$

$I_2 = S E_2 / Z_2'$

Rotor circuit (at running)

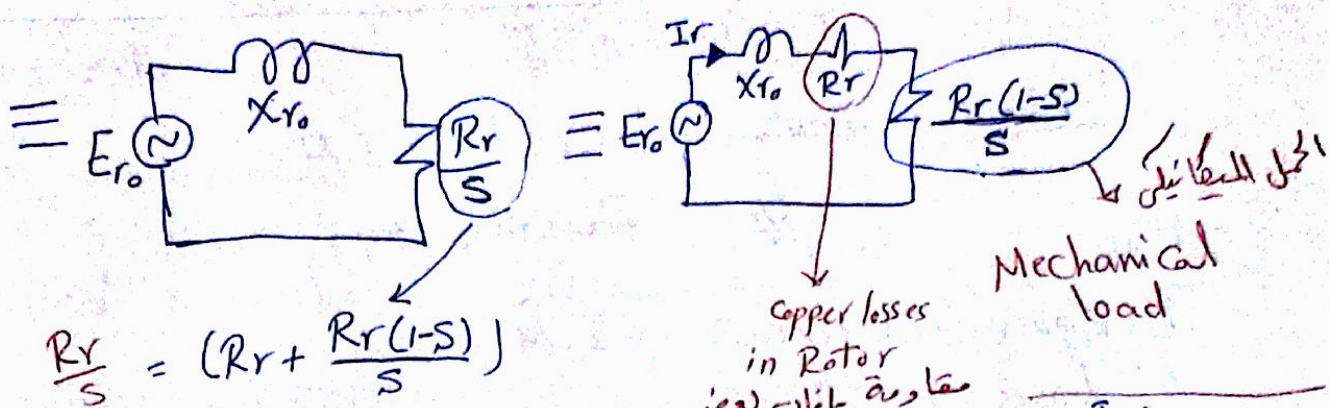


rotor current $= I_r = \dfrac{E_r}{(R_r + jX_r)}$

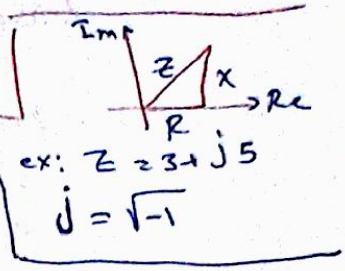
$= \dfrac{SE_{r_0}}{(R_r + jX_{r_0})} = \dfrac{E_{r_0}}{\left(\dfrac{R_r}{S} + jX_{r_0}\right)}$

* E_{r_0} = largest value of induced voltage at $S=1$

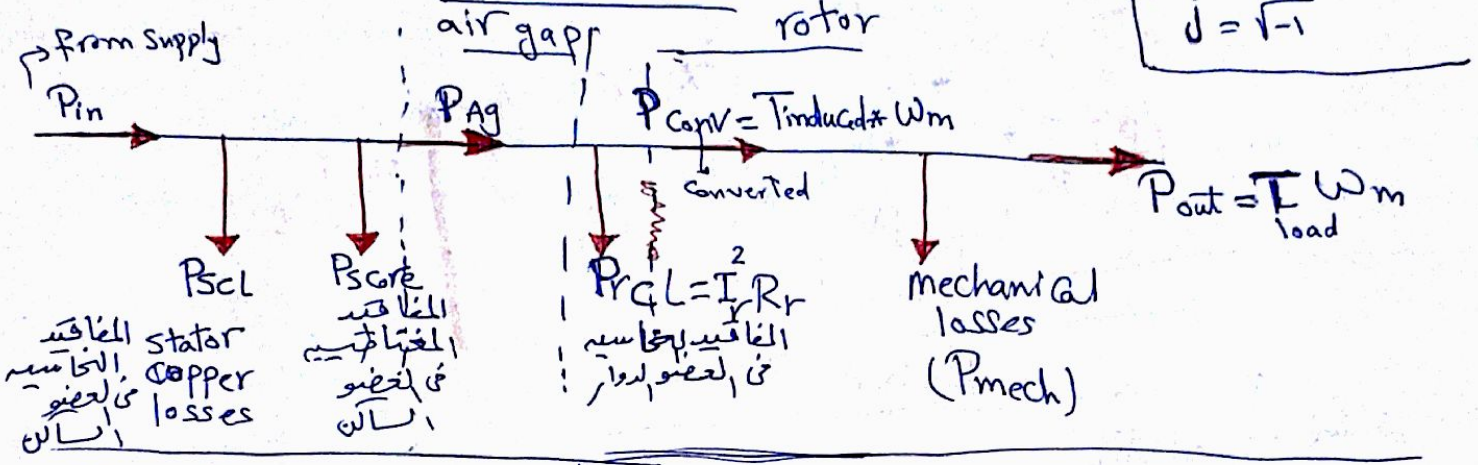
* $X_{r_0} = 2\pi f L$



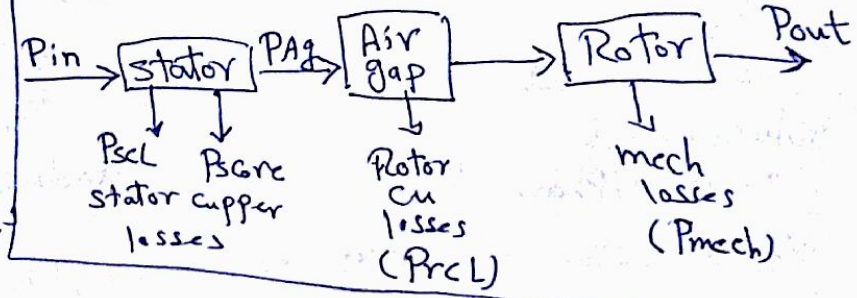
$$\frac{Rr}{S} = \left(Rr + \frac{Rr(1-S)}{S}\right)$$



Power flow

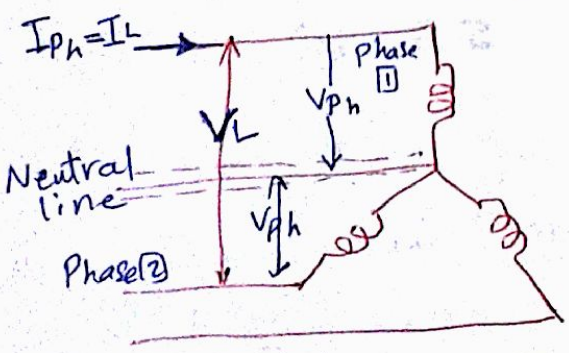


* $P_{in} = P_{Ag} + P_{scL} + P_{scGre}$
* $P_{Ag} = P_{conv} + P_{rcL}$
* $P_{conv} = P_{out} + P_{mech}$

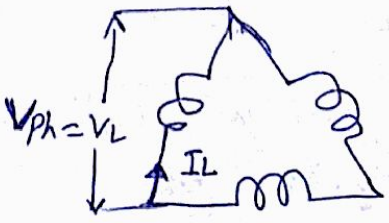


Math Rules

P_{in} = input Power = $3 V_{ph} I_{ph}$



star



Delta

$$P_{in} = \sqrt{3}\, V_L I_L \cos\phi = 3 V_{ph} I_{V_{ph}} \cos\phi$$

$$P_{SCL} = 3 I_1^2 R_1$$

$$P_{in} = P_{AG} + P_{SCL} + P_{Score}$$

$$P_{AG} = P_{in} - (P_{SCL} + P_{Score})$$

$$P_{AG} = P_{conv} + P_{RCL}$$

$$P_{AG} = 3 I_2^2 \left[\frac{R_2 (1-S)}{S}\right] + 3 I_2^2 R_2$$

$$P_{AG} = \frac{P_{rcl}}{S} \rightarrow \frac{3 I_2^2 R_2}{S}$$

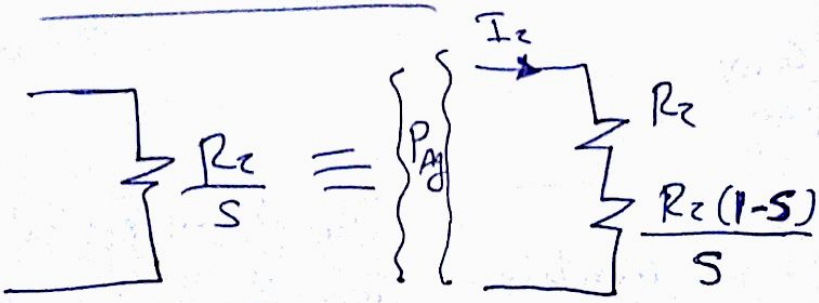
$$P_{conv} = P_{AG} - P_{rcl} = \frac{P_{RCL}(1-S)}{S}$$

$$T_{induced} = \frac{P_{con}}{\omega_m} = \frac{(1-S) P_{AG}}{(1-S)\omega_S}$$

$$P_{out} = P_{conv} - (\text{fricition losses} + \text{Stray losses})$$

$$T_{load} = \frac{P_{out}}{\omega_m}$$

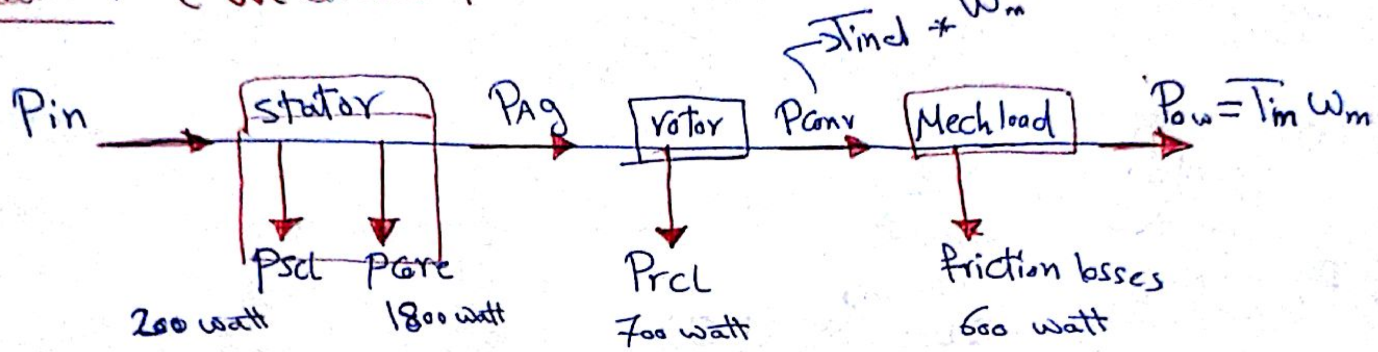
$$\omega_m \simeq \frac{2\pi n_w}{60}$$



A (480) volt, (60) Hz, (50) HP three phase induction motor is drawing (60) A at (0.85) Power factor lagging, stator copper losses are (2 Kw), rotor copper losses are (700) watt friction & windage losses are (600) watt, Core losses are (1800) watt

<u>find</u> : P_{Ag}, P_{conv}, P_{out}, $\eta\% = \frac{P_{out}}{P_{in}} \times 100$

<u>solution</u>: (we draw power flow)



$P_{in} = \sqrt{3}\, V_L I_L \cos\phi = \sqrt{3} * 480 * 60 * 0.85 = [\ ]$ watt

$P_{Ag} = P_{in} - (P_{scl} + P_{core})$

$P_{conv} = P_{Ag} - P_{rcl}$

$P_{out} = P_{con} - (\text{Mech. losses})$

$\eta_{stator} = \frac{P_{Ag}}{P_{in}}$

$\eta_{rotor} = \frac{P_{conv}}{P_{Ag}}$

* الأمثلة على المحاضرة [١٠،٩]
في الفاينال
الكتاب ص 157 , ص 158

** توقع الأسئلة النظري في امتحان الفاينال

* Construction of [Dc machine, Transformer, Induction Motor]
* Principle operation of → generation
  → Motor
  → Transformer
  → Induction Motor

* Question about losses ?